PATENT APPLICATION

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TITLE: METHOD OF USING SHORT WAVELENGTH UV LIGHT TO SELECTIVELY REMOVE A COATING FROM A SUBSTRATE AND ARTICLE PRODUCED THEREBY

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ATTORNEY DOCKET: 1-15092

"Express Mail" Mailing Label Number EL 469907379US Date of Deposit November 29, 2001 I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to the U.S. Patent & Trademark Office, P.O. Box 2327, Arlington, VA 22202.

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METHOD OF USING SHORT WAVELENGTH UV LIGHT TO SELECTIVELY REMOVE A COATING FROM A SUBSTRATE AND ARTICLE PRODUCED THEREBY

BACKGROUND

A method of removing a selected portion of a coating from a substrate is disclosed. More particularly, a method of removing a functional organic coating, for example, a coating having hydrophobic properties, with short wavelength ultraviolet (UV) light from a non-conductive substrate is disclosed.

Various types of coatings are often applied to non-conductive substrates such as glass to impart different properties to the substrate. One such property which may be imparted to a substrate, such as glass, by a coating, is that of hydrophobicity. Hydrophobic coatings cause water to bead readily and run off quickly. One application where this property is useful is in the field of vehicle glazing. Application of a hydrophobic coating to a glazing in a vehicle, such as an automobile windshield, backlight or sidelight can, by its properties, cause water which comes into contact with the coating to form into beads and quickly run off the glazing so as not to obscure the outward vision of the occupants of the vehicle. Particularly for the operator of the vehicle, clearer vision is a safety benefit.

Much effort is expended in applying such hydrophobic coatings to a substrate, such as a vehicle glazing, to ensure that the coating strongly adheres to the substrate. It is, clearly, undesirable for the coating to begin to peel off the substrate, both from a functional and an aesthetic viewpoint.

It may be desirable, however, in some cases, to intentionally remove the coating from the substrate in selected areas. Such selective removal may be desirable, for example, if one wishes to adhere an item to the substrate. In the case of vehicle glazings, it is often desirable to adhere one or more gaskets to portions of the peripheral edge of the glazing. It might also be desirable to adhere an item of hardware, such as a fastening device, a mounting device, or the like, in a particular location on the glazing.

Typically, hydrophobic coatings do not readily allow adhesive materials to adhere to them. So, in order to adhere a gasket or an item of hardware to the substrate, the coating must be removed, or it must have been selectively prevented from having been applied to the substrate in the first instance.

To date, efforts to solve this problem have been directed, primarily, to selectively preventing the coating from being applied to the substrate. One method of selectively preventing application of the coating is by masking the area where no coating is desired by applying an adhesive tape, a resist material, or the like, over those areas in which the coating is not desired.

While these methods are generally effective in preventing the application of the coating, they are uniformly costly, both in the cost of the masking materials and the labor necessary to apply them. Such masking also adds a lengthy step to the manufacturing process, thus greatly increasing cycle time when, for example, one is manufacturing high volume vehicle glazings.

Accordingly, it would be desirable to have a means to eliminate the need for costly operations, such as masking, and instead to have a quick and cost-efficient method to selectively remove an organic functional coating, such as a hydrophobic coating, from a non-conductive substrate, such as glass, and one which could be readily incorporated into a time-critical, automated manufacturing process.

SUMMARY OF THE INVENTION

It has been discovered that selective removal of such organic functional coatings can be efficiently accomplished by exposing the coated substrate to a source of short wavelength UV light. By short wavelength UV light is meant light having a dominant wavelength in the range of 5 nm to 254 nm. Preferably, the dominant wavelength of the UV light is from 100 nm to 200 nm. Most preferably, the dominant wavelength of the UV light is 172 nm.

More specifically, the present invention involves the selective removal of organic functional coatings having hydrophobic properties from the surface of a dielectric substrate, such as glass, in order to promote adhesion to that portion of the substrate from which the coating has been removed.

To selectively remove the organic functional coating from a large area of a dielectric substrate, for example, around the entire periphery of a vehicle glazing, or for the selective removal of such a coating from a substrate of large dimension, for example, a vehicle windshield or backlite, multiple sources of short wavelength UV light may be used.

Alternatively, a system of moving one or more sources of short wavelength UV light in a pre-determined pattern by electro-mechanical or opto-electro-mechanical means, for example, a robot arm, or a robot arm directed by an optical "vision system", may be utilized to selectively remove organic functional coatings.

The present invention also includes the article produced by the previously described method, particularly an automotive glazing from which an organic functional coating, such as a coating having hydrophobic properties, has been selectively removed.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic layout of a short wavelength UV light removal system.

Fig. 2 is a cross-sectional view of a dielectric substrate carrying an organic functional coating, a portion of which has been removed by exposure to short wavelength UV light.

Fig. 3 is a cross-sectional view of a dielectric substrate as in Fig. 2 showing a fastening device adhered to the portion of the substrate from which the organic functional coating has been removed.

Figs. 4 and 5 are cross-sectional views showing the difference in the water contact angle of a water droplet on a substrate where the organic functional coating is intact, and where a portion of the coating has been removed, respectively.

Figs. 6 and 7 are plan views showing examples of how organic functional coatings may be selectively removed utilizing the present invention.

Fig. 8 is a graphical representation of the change in water contact angle with time of exposure to short wavelength UV light.

DETAILED DESCRIPTION OF THE INVENTION

In order to accomplish the desired selective removal of organic functional coatings, the source of the short wavelength UV 14 light must be capable of emitting a beam of light which is primarily comprised of a single, dominant wavelength. Examples of such light sources are lasers, and excimer lamps. Manufacturers of suitable excimer lamps are, for example, Ushio Inc. and Heraeus (?).

Such light sources 14 should also be capable of being focused on precisely defined portions of the coated substrate 10 from which removal of the coating 12 is desired. For example, the above-mentioned lasers and excimer lamps have been demonstrated to remove coatings 12 to a precision of +/- 1 mm.

Further, for purposes of the present invention, it is important that the source of short wavelength UV 14 light be capable of removing the organic functional coating 12 within a relatively short exposure period, so that the coating removal operation may be incorporated into a time-critical manufacturing process, such as the high-volume production of automotive glazings. To this end, it has been determined that organic functional coatings 12 such as polysiloxanes, polyfluorosiloxanes and diamond-like carbon may be effectively removed by exposure to short wavelength UV light, having a dominant wavelength of about 172 nm, in a range of 5 to 120 seconds. It has also been determined that such exposure times may be longer or shorter depending on the "strength" of the light source 14. By "strength" of the light source is meant the number of watts of power transmitted to the coated surface per unit area, for example, units per square centimeter. Further, it has been determined that the distance between the light source and the surface of the coating is important to removal efficiency. For the lamp tested, having a "strength" of 50 watts/cm^2, optimal distance between the lamp and coating surface is 0 to 2 mm.

The effective removal of the organic functional coating 12 by exposure to the short wavelength UV light can be determined by measuring the water contact angle 26 both before and after the prescribed exposure period. The "water contact angle" 26 is the angle measured from the horizontal, between the base of a water droplet which is in contact with the coated substrate 10, 12 and the surface of the substrate, or the surface of the substrate from which the coating has been removed 20. The water contact angle 26 is, typically, measured by a visual enhancement system, for example, the system manufactured by AST Products, and a computer software package, for example, the package sold under the name VCA-2000 for Windows.

Utilizing the method of the subject invention, it has been found that the water contact angle 26 was reduced from greater than 100° to less than 30°, after exposure to the UV light, thus indicating that the coating 12 had been effectively removed from the desired area.

Once the organic functional coating 12 has been removed, the selected area may be made ready to have, for example, an elastomeric member or item of hardware attached to it. Preferably, an adhesion promoting primer 21, such as a silane primer, is applied to the selected area, after which an appropriate adhesive 22 is applied.

The elastomeric member may be, for example, a type of gasket. The adhesive 22 may be, any suitable adhesive, for example, cyanoacrylate, urethane, epoxy, acrylic, hot melt silicone, or pressure sensitive adhesives.

Table 1 shows the results of several experiments wherein the time of exposure of the organic functional coating 12 to the short wave UV light 14 was doubled in Tests 1-5 but then was increased by 20 seconds for Test 6. Column A shows the change in water contact angle with exposure time as the hydrophobic coating is affected by the short wavelength UV light. "Tin side" refers to the major surface of the glass substrate which was in contact with the molten tin of the float bath during the glass manufacturing process. The hydrophobic coating had been deposited on that major surface of the substrate, and so was the side treated. Column B shows results for treatment of the coating also on the tin side of the glass substrate with the short wavelength UV light source at a distance of 7.7 mm from the surface of the organic functional coating. The change in water contact angle is significantly less dramatic than Column A where the distance between the UV light source and the coated surface was between 0 and 2 mm. As can be seen, the water contact angle 26 decreased significantly in all cases after a 40-second exposure, and with respect to Column A, had decreased significantly after only a 20-second exposure. It is applicant's opinion that with respect to Column A, the water contact angle 26 of 10° ± 3° after a 60-second exposure shows that the organic functional coating has been substantially completely removed.

The water contact angle in these tests was measured by the methodology previously described herein.

Table 2 shows the results of various tests to demonstrate the effectiveness of removal of the organic functional coating 12 in relation to the strength of the adhesive bond created when standard adhesion promoting primers 21, compatible adhesives 22 and an attachment means 24 are applied to an area from which the coating has been removed 20 by exposure to short wavelength UV light. The time intervals of exposure carry over from the tests shown in Table 1. Columns A-C show the dynamic load necessary to break the adhesive bond, and the predominant failure mode(s).

More specifically, column A shows results of exposure where the organic functional coating was deposited over a previously applied, typically by silk-screening, layer of a mixture of powdered glass, color pigment, and optionally, a powdered electrically conductive metal, such as silver.

Columns B and C shows the relative effectiveness of removal where the organic functional coating was deposited on the side of the glass in contact with the molten tin in the float bath (Column B), and where the organic functional coating had been deposited on the major surface of the glass which, in the glass manufacturing process, does not come into contact with the molten tin in the float bath, also known as the "air side" (Column C).

It can be seen that substantially improved adhesion was obtained in all cases after 40 seconds exposure to short wavelength UV light. Except for Column B, maximum adhesion occurred after 60 seconds exposure. After 60 seconds exposure, the adhesive bond was stronger than the glass substrate to which it was attached, as denoted by the predominant failure mode.

Table 1 – Effect of Short Wavelength UV Exposure on Water Contact Angle

	Treatment Time	(A) Contact Angle Tin Side	(B) Contact Angle 7.7mm shim
1	No treatment	111° ± 1°	111° ± 1°
2	5 seconds	83° ± 26°	No change
3	10 seconds	67° ± 22°	No change
4	20 seconds	31° ± 12°	109° ± 2°
5	40 seconds	19° ± 9°	80° ± 29°
6	60 seconds	10° ± 3°	100° ± 14°

Table 2 – Effect of Short Wavelength UV Exposure on Adhesion to Glass Substrate or Glass Substrate to which a Frit has been Applied

	Treatment Time	(A) AT3513 frit		(B) Tin Side		(C) Air Side	
		Shear Failure Load	Predominant Failure Mode(s)	Shear Failure Load	Predominant Failure Mode(s)	Shear Failure Load	Predominant Failure Mode(s)
1	No treatment	301° ± 111 lbs.	PG	89° ± 38 lbs.	PG	54° ± 29 lbs.	PG
2	5 seconds	323° ± 82 lbs.	PG	211° ± 103 lbs.	PG, GB	335° ± 132 lbs.	LCFM, LCFG, PG
3	10 seconds	453° ± 318 lbs.	PG	539° ± 98 lbs.	PG, LCFG	557° ± 168 lbs.	LCFM, LCFG
4	20 seconds	435° ± 141 lbs.	PG, LCFG	670° ± 100 lbs.	LCFG, PG, GB	380° ± 159 lbs.	LCFM, PG
5	40 seconds	659° ± 71 lbs.	PG, GB	662° ± 113 lbs.	LCFG, GB, CF, LCFM, PG	408° ± 47 lbs.	LCFM
6	60 seconds	682° ± 58 lbs.	GB	600° ± 226 lbs.	LCFG, GB, PG	594° ± 224 lbs.	LCFM, LCFG, GB

Notes: Adhesive = Essex 73100/73005, Primer = 43518/43520A, Substrate 2 = E-coated steel, Bond area = 0.5 x 1"
Hydrophobic coating (NSG primer type) applied to glass using PNA pilot line
43518 primer wipe-on/wipe-off, 43520A = 30-minute cure at 70°F, 50% R.H., 24-hour (min) adhesive cure
UV treatment at PNA using Ushio handheld light
Samples tested in Instron at 10mm/min.
Sample assembly and testing by Andrea Schult

Table 3 shows the effects of exposure on multiple samples of glass carrying a hydrophobic coating to short wavelength UV light on the water contact angle in order to determine the repeatability of efficiently removing the coating. The exposure times are the same as in Tables 1 and 2. It can be seen that the water contact angle changes erratically with short exposure time (5-10 secs.) but becomes more predictable with exposure time of 15-60 seconds (See Columns A-C). Coating removal has been, essentially and repeatably, achieved after exposure of 40 seconds.

Table 3 – Reproducibility of Effect of Exposure to 172nm UV Lamp on Sidelights Coated Samples

Sample	Time (s)	(A) Contact Angle 1	(B) Contact Angle 2	(C) Contact Angle 3	(D) Average	(E) Stdev
1	**5**	107.3	77.6	72.7	**85.87**	18.72
2	**10**	75.2	91.8	63.4	**76.80**	14.27
3	**15**	45.6	35.2	40.8	**40.53**	5.21
4	**20**	32.7	26.4	26.4	**28.50**	3.64
5	**40**	18.9	20.1	23	**20.67**	2.11
6	**60**	20.1	17.7	20.1	**19.30**	1.39

In accordance with the provisions of the patent statutes, the present invention has been described in what is considered to represent its preferred embodiment, however, it should be noted that the invention can be practiced otherwise than as specifically illustrated and described without departing from its spirit and scope.